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PROPOSED AUDITORY DAMAGE RISK CRITERIA FOR THE NAVY

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Investigator:

J. Donald Harris

Submitted by:

J D Harris

J. Donald Harris, Ph.D.,
Head, Special Senses Branch

Reviewed and Approved by:

Charles F. Gell

Charles F. Gell, M.D., D.Sc.
Scientific Director

Approved and Released by:

Gerald J. Duffner

Gerald J. Duffner
Captain, MC USN
Commanding Officer

SUMMARY PAGE

THE PROBLEM

To provide Auditory Damage Risk Criteria (DRC) for the protection of hearing of Navy personnel exposed to noise.

FINDINGS

The results of a great deal of recent information on noise exposure and hearing loss were compressed into four easily-understood tables giving DRC for pure tones, continuous noise, and intermittent noise. It was not possible at this time to write DRC for impulsive noise such as gunfire.

APPLICATION

This information is for the guidance of those involved in revisions of Navy instructions on hearing conservation, new ship construction, work-space habitability, ecetera.

ADMINISTRATIVE INFORMATION

This investigation was conducted as a part of Bureau of Medicine and Surgery Research Work Unit MF022.01.03-9004 - Optimizing of Special Senses in Submarine and Diving Operations. The present report is No. 4 on this Work Unit. It was approved for publication on 30 January 1968 and designated as Memorandum Report No. 68-2.

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PROPOSED AUDITORY DAMAGE RISK CRITERIA FOR THE NAVY

1. Background:

a. Previous Action.

A Damage Risk Criterion (DRC) was incorporated into BUMEDINST 6260.6A in 1959, stating that the full provisions of a specified Hearing Conservation Program were to be carried out including audiometry, use of protective devices, etc. whenever the noise in a workspace to which a worker was exposed 8 hours a day reached 85 dB (recommended; 95 dB mandatory) at one or more of the octaves 300-600, 600-1200, 1200-2400, 2400-4800 cycles per second (cps).

b. Source of Previous DRC.

The previous DRC was based upon a report of Exploratory Subcommittee Z-24-X-2 of the American Standards Association, "The Relations of Hearing Loss to Noise Exposure" in 1954, W. A. Rosenblith, Chairman; and coincides with the DRC expressed in Air Force Regulation No. 160-3 of 29 October 1956.

c. Need for Revision of DRC.

The previous DRC was based on what was then known of hearing loss in industry. In the years since, a mass of information on the problem has been compiled. It has been digested and codified by several nationally recognized groups, and a distinct difference in noise susceptibility has been shown between the industrial population and a population of young healthy sailors. It is now time to rewrite the Navy's DRC in the light of these new data. New information is available on the effect of frequency spectrum, duration of exposure, and the temporal pattern of the noise through the working day.

2. Current Views of DRC:

a. Committee on Hearing, Bioacoustics, and Biomechanics (CHABA).

The most extensive up-to-date summary of DRC, by CHABA Working Group 46 (WG 46) has been published in the Journal of the Acoustical Society of America, 1966, Vol. 33, pp. 451-464. Any current DRC must agree closely with the provisions of this document if it is to be in any way authoritative.

- b. Subcommittee on Noise of the Committee on Conservation of Hearing, Amer. Acad. Ophthalmol. and Otolaryngol. "Guide for Conservation of Hearing in Noise", 1964.

This committee of outstanding specialists has recommended a DRC of 85 dB (ave. of SPL at 300-600, 600-1200, 1200-2400 cps). They further list the maximum exposure duration per day at SPLs from 85-120 dB, and furnish a figure dealing with "on-time" and "off-time" combinations of intermittent noise exposure.

- c. U.S. America Standards Institute, Technical Committee S3.10/115.

This group is preparing a final draft of what is essentially a combination of the deliberations of groups (a) and (b) above.

- d. Ad Hoc Intersociety Committee on Guidelines for Noise Exposure Control (Indus. Med. Assoc.; Amer. Indus. Hygiene Assoc.; AAOO; Amer. Acad. Occup. Med.; Amer. Conf. Gov't. Indus. Hygienists) Report, 1967.

This group ties its DRC to the age of the workers. Thus, DRC are more stringent for the worker in the fifth decade of life than in the third, according to a figure presented; much of this data, available only to the committee, was provided by the subcommittee members of group (b) above. The DRC is raised 5 dB for each halving of the daily work noise-exposure. The allowance for intermittent exposure is taken directly from (b) above.

3. Need for Simplifying the DRC of CHABA Working Group 46:

The DRC of CHABA WG 46 is the fullest statement of what is presently known, and should be circulated and used widely wherever possible. However, the wording and treatment were not intended to be used as a general field guide. It is invaluable as a reference, but it is necessary to simplify and abstract it so that its provisions will have the widest possible application. It is the intent of this draft to perform such a function.

4. Bases of DRC Here Proposed:

- a. Relevant Frequency Regions:

Although WG 46 incorporated the frequencies 100-7000 cps in its

DRC, groups (b, c, d) above suggest that only the frequency regions centered on 500, 1000, and 2000 cps need be considered. The DRC contained in the tables below consider only these three frequency regions. However, Figure 1 gives the complete frequency range after WG 46, to serve as a guide for revisions of such NavShipSysCommand reports as "Criteria for setting airborne noise level limits in shipboard spaces", and "Noise level limits for the avoidance of deafness in shipboard machinery spaces", and for those generally concerned with the habitability of workspaces throughout the Navy.

b. Use of the "A" Scale of the Sound Level Meter.

Although use of the single filter incorporated into the "A" scale is a violation of the principle that each frequency region must meet a safe criterion, the use of the "A" scale can be justified, though it leads to some loss of precision, for broadband noises of gently sloping spectra, if a better filter is really unobtainable. The "A" scale can at least identify potentially dangerous areas, and lead to conservation measures being applied. In the case of a noise on the borderline of a DRC, more exact filtering should be obtained.

c. Octave-Band and Third-Octave-Band Filtering.

Noises of interest in industry and throughout the DOD are generally of such broad frequency spectrum that either octave-band or third-octave-band filtering is equally applicable. Octave-band filters are cheaper and of course commoner. Figure 1 is to be used with data from octave-band filters. However, the same figure can be used correctly if the noise survey is taken with a third-octave filter set, as stated below. A third-octave set has an advantage: if the workspace contains a pronounced pure-tone component, which (because the energy is concentrated more on a specific region of the inner ear) is more damaging than energy of the same total SPL but spread over an octave, the third-octave filter set can be used to specify closely enough what frequency is present, and thus to enter Table II to find the DRC for that pure tone.

d. Adjustment for Durations of Noise Exposure Shorter than 1 Working Day.

Air Force Regulation 160-3 credited 3 dB for every halving of exposure duration. Group (d) above credits 5 dB. Groups (a, b, c) agree that the adjustment is too complicated for any single conversion factor. Figure 1 contains the solution offered by WG 46 to this problem. Note, however, that for the purposes of this Instruction, Figure 1 is to be used only at 500, 1000, and 2000 cps.

e. Adjustments for Intermittent Noise.

There is information today on the effects of noise-burst duration, repetition rate, recovery time from each noise burst, and total exposure for any SPL over a working day, to a variety of intermittent noises. DRC for these conditions are summarized in eight rather complicated figures by WG 46. These data have been abstracted in two tables in this draft; it is considered that interpolating within these tables will give adequate guidance with nevertheless acceptable simplicity for handling an inherently complex set of parameters.

f. Differences Between an Industrial and a Navy Population.

Data in the report of Group (d) above imply a greater susceptibility to damage from noise on the part of the older industrial worker. Furthermore, a seven-year longitudinal study of several hundred Navy enginemen (see the Journal of the Acoustical Society of America, 1965, Vol. 37, pp. 444-452) revealed reliably less permanent threshold shift (hearing loss) than predicted by the principles and data from industrial populations on which WG 46 based its figures. A major difference is the mean age difference of some decades. For this reason, the DRC of this draft uses the actual figures of WG 46 but assigns a 5-dB more lenient (i.e., higher) SPL at all frequencies as a conservative age factor.

5. Proposed Section "Damage Risk Criteria" for a Revision of BUMEDINST 6260.6A of January 1959 "Hearing Conservation Program":

DAMAGE RISK CRITERIA

1. Definition of Noise Exposure:

Noise exposure is to be noted in terms of sound pressure level (SPL) and distribution over a typical working day.

- 1.1. SPL can be specified with a sound level meter set on the "A" scale, which attempts to match the meter to the characteristics of the human ear.
- 1.2. SPL is preferably measured with a sound level meter incorporating a selection of octave-band or third-octave-band filters.

2. Permissible Noise Exposure

2.1. Intent.

The DRC in this Instruction is designed to protect 90% of a Navy population (no permanent threshold shift over 25 dB on the average for 500, 1000, and 2000 cycles per second (cps). The 10% most-susceptible ears are to be protected by audiometry, protective devices, etc. as outlined elsewhere in this Instruction.

2.2. Background.

The DRC herein are not based upon averages of, or weighted preferences for, any set of previous DRC, but are derived from a fresh consideration of all available data by Working Group 46 of the NAS-NRC Committee on Hearing, Bioacoustics, and Biomechanics (ONR Contract No. NONR 2300 (05)). A full treatment is found in the Journal of the Acoustical Society of America, 1966, Vol. 39, pp. 451-464. These data accord generally with a document now being circulated by the U.S. America Standards Institute Technical Committee S3.10/115 "Proposed American Standard Permissible Noise Exposures for Hearing Conservation", and by the Committee on Conservation of Hearing of the Amer. Acad. Ophthalmol. and Otolaryngol., "Guide for Conservation of Hearing in Noise", 1964.

2.3. Permissible SPL Using Sound Level Meter set on "A" Scale.

Such measurements are permissible and valid only when it can be assumed that the octave-band spectrum of the noise is flat or nearly so over the region 500-2000 cps, or falls off toward the higher frequencies. This is often, but not always, the case for noise in the Navy. Whenever it is suspected not to be the case, octave-band SPL readings should be obtained. For many noises, the reading on the "A" scale will be 5 dB greater than the reading of an octave-band filter centering on 2000 cps. Where only "A" scale readings are available, then, it is necessary first to subtract 5 dB from the "A" scale reading, and then to find DRC by entering the tables below for the octave-band centered around 2000 cps.

2.4. Permissible SPL from Sound Level Meter Using Octave-Band or Third-Octave-Band Filters.

- 2.4.1. For Continuous Exposures to Steady-State Noise. Table I gives the SPLs which must not be exceeded, for each of the three relevant frequency regions, for a selection of daily exposure durations. Interpolation can be done by simple arithmetic.

Note: Table I is for octave-band filtering. If third-octave-band filtering is available, simply add 5dB to each such reading before entering Table I.

- 2.4.2. For Continuous Exposures to Pure Tones. Exposure to pure tones is complicated by the fact that the energy is concentrated on specific portions of the inner ear and is therefore more damaging, and by the fact that the middle ear muscle protective reflex affects the lower frequencies, not the higher. Table II summarizes the DRC for pure tones.

- 2.4.3. For Intermittent Exposures to Noise.

2.4.3.1. Relatively Long Noise-Burst Duration. There are situations in which a high-intensity noise (two minutes or more in duration) is repeated infrequently or irregularly through the day. Table III gives the recovery time which must elapse between any two such bursts.

2.4.3.2. Relatively Short Noise-Burst Duration. There are situations in which brief (two minutes or less) high-intensity noise bursts are repeated rather rapidly for some minutes or hours through the day. Table IV gives the maximum permissible length of one session per day of such a "picket-fence" noise.

- 2.5 For Impulsive Noises.

DRC cannot be specified at this time. Research on peak SPL repetition rate, spectrum, etc. is continuing.

Table I - Damage Risk Criteria for Continuous Exposure

TABLE I DAMAGE RISK CRITERIA FOR CONTINUOUS EXPOSURE				
ENTRY: SPLs AT WHICH THE PROVISIONS OF THIS INSTRUCTION BECOME MANDATORY				
Permissible Daily Exposure in Minutes	Band No. 1 300-600	Band No. 2 600-1200	Band No. 3 1200-2400	Sound Level Meter on "A" Scale
480	93	91	90	95
240	97	93	91	96
120	100	97	93	98
60	103	100	97	102
30	110	105	100	105
15	117	111	104	109
7	125	119	111	116
3	135	130	118	123

Notes: (1) No exposure should exceed 135 dB SPL.

(2) For third-octave-band filters, add 5 dB to each third-octave-band reading before entering table.

Table II - Damage Risk Criteria for Continuous Pure Tones

TABLE II DAMAGE RISK CRITERIA FOR CONTINUOUS PURE TONES							
Frequency in CPS	Daily Exposure Duration in Minutes						
	3	5	10	30	60	120	480
300	126	122	112	104	97	95	90
500	122	117	108	102	96	93	88
750	119	115	106	99	94	91	87
1000	118	114	104	98	93	90	86
2000	113	109	102	95	92	88	85
3000	110	106	98	93	89	87	85

Entry: SPLs at which the provisions of this instruction became mandatory

TABLE III

NECESSARY RECOVERY TIMES BETWEEN NOISE BURSTS OF RELATIVELY LONG DURATION

SPL	Band No.	Noise Duration in Minutes				SPL	Band No.	Noise Duration in Minutes			
		3	5	10	30			3	5	10	30
95	1	-	-	-	-	115	1	-	3.3	7	*
	2	-	-	-	3.3		2	6.3	13	*	
	3	-	-	-	3.5		3	48	*		
100	1	-	-	-	-	120	1	4.2	6.8	45	*
	2	-	-	-	5.3		2	14	65	*	
	3	-	-	3.9	60		3	*			
105	1	-	-	-	5.7	125	1	6.3	16	*	
	2	-	-	4	*		2	45	*		
	3	3.7	5.2	<u>16</u>	*		3	*			
110	1	-	-	3.6	30	130	1	16	*		
	2	3	4.8	13	*		2	*			
	3	7.7	27	*	*		3	*			
	1	-	-	-	-	135	1	65	*		
	2	-	-	-	-		2	*			
	3	-	-	-	-		3	*			

*: Give only once per day

Note: Band No. as in Table I

Example: A burst of noise in Band 3 at 105 dB SPL for 10 minutes would require a recovery period of 16 minutes before another burst occurred. (Example underlined in Table)

TABLE IV

PERMISSIBLE LENGTH IN MINUTES OF ONE SESSION A DAY CONSISTING
OF SHORT-BURST NOISE-QUIET CYCLES

Noise On-Fraction	95			105			115			125			135		
	Band Number			Band Number			Band Number			Band Number			Band Number		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	4
0.8	480	400	250	150	<u>65</u>	32	45	22	9	19	9	4	8	4	X
0.6	480	480	480	480	140	80	120	41	22	48	17	9	23	9	X
0.4	480	480	480	480	480	480	480	180	90	350	61	30	150	29	X

Note: Band No. as in Table I.

Individual Noise Bursts must be no longer than 2 minutes

Example: An intermittent noise of 105 dB SPL at Band 2 can be listened to for one 65-minute session per day if the noise is 2-min in duration, with 30-second quiet periods interspersed (0.8 on-time fraction) (Example underlined in Table)

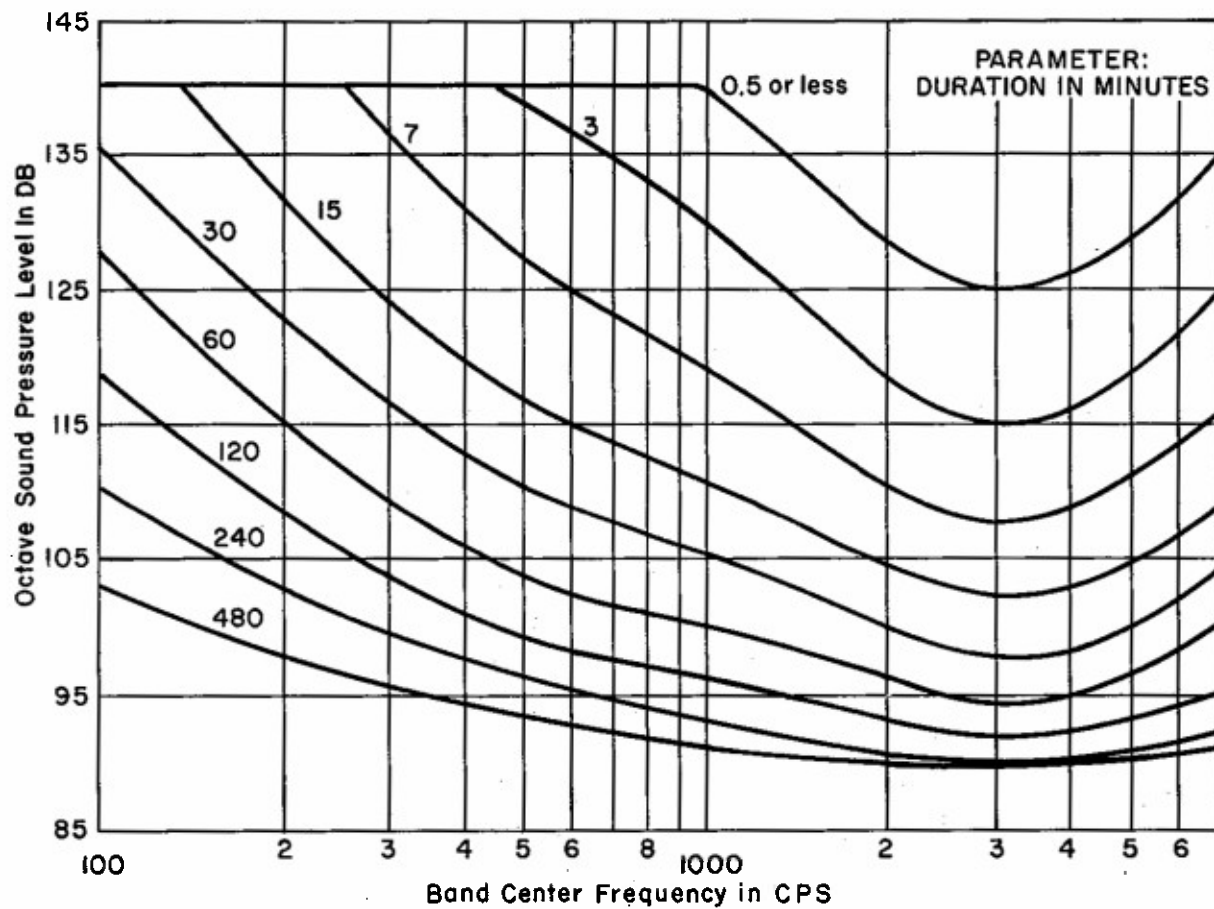


Figure 1. - Damage Risk Criteria in Permissible Sound Pressure Level for Octave-Band-Filtered Noise at a Selection of Exposure Durations Through the Working Day.

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13. ABSTRACT The results of the latest thinking of several nationally recognized groups on the problem of noise exposure and hearing loss have been summarized into four tables. Auditory Damage Risk Criteria in the form of permissible Sound Pressure Levels are provided for pure tones, steady-state noises, and intermittent noises, for a selection of minutes-exposure during a typical working day. The criteria are limited to the frequency regions 500-2000 cycles per second.		

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Permissible sound pressure levels

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